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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Preparing Activity: KSC

NASA/KSC-27 13 23.01 98 (October 2007)

Superseding
NASA/KSC-27 13 23.01 98 (April 2006)

NASA/KSC GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2009

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DIVISION 27 - COMMUNICATIONS

SECTION 27 13 23.01 98

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING (LTD)

10/07

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SECTION 27 13 23.01 98

COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING (LTD)
10/07

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NOTE: This specification covers the requirements for requirements for the fiber cabling system of the outside cable plant. Accordingly, carefully tailor this section to suit project conditions and to meet project requirements.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.
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PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text are automatically deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

JOHN F. KENNEDY SPACE CENTER (KSC)

79K28125	(1996) Fiber Optic Cable Specification for Kennedy Space Center

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition

1.2 GENERAL REQUIREMENTS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 Submittals and edit the following list to reflect only the submittals required for the project. Keep submittals to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

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1.2.1 Scope

This section covers the requirements for fiber optic cables and associated components. The fiber optic cable must consist of optical fibers, strength member (or members), filling compound and jacketing. The associated components must include optical fiber connectors, fiber optic terminal assemblies, terminal bay cabinets, and splice closures as indicated. Install the fiber optic cables in inner duct in the existing cable duct and manhole system. Locate the fiber optic terminal equipment in existing facility buildings.

Install and splice all cables as specified herein and on the drawings.

Unless otherwise specified, all references in Section 27 13 23.01 98 COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING to cable must be deemed to mean fiber optic cable.

1.3 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Keep submittals to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the

submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, use a code of up to three characters within the submittal tags following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that reviews the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Optical Fibers (uncabled)
Fiber Optic Cable
Splice Organizers and Enclosures
Splice Trays
Encapsulating Compound
Pre-Connectorized Cable Assemblies
Connector Feedthrough Adapter
Fiber Optic Terminal (FOT) Bay Cabinet
High Density FOT Cross-Connect System

SD-06 Test Reports

Provide a Fiber Cable acceptance test plan at least 30 days prior to testing.

Installed Fiber Cabling Acceptance Test Plan

Test Results for Optical Fibers (uncabled)
Fiber Optic cable (reeled and installed)
Pre-connectorized Cable Assemblies

SD-07 Certificates

Provide a Certificate of Compliance for each of the following

items:

Optical fibers (uncabled) as defined by paragraph 8.1 of Specification 79K28125, Revision K.

Fiber Optic Cable as defined by paragraph 8.2 of Specification 79K28125, Revision K.

OFNR Cable NEC Fire Rating.

OFNP Cable NEC Fire Rating.

PART 2 PRODUCTS

2.1 CABLE

The cable must be manufactured in accordance with the requirements of KSC Specification 79K28125, and as indicated herein. The cable manufacturer must provide a warranty on the cable for a period of at least five (5) years. Unless otherwise shown on drawings, all cables routed in buildings for a distance of greater than 15 m50 feet must transition to riser or plenum rated cables and conform with the OFNR/OFNP cable requirements of NFPA 70, Article 770. All contractor provided fiber must be of the same type, specification, and manufacturer. Changes to the KSC Specification are indicated below.

2.1.1 Quantities and Colors of Fibers and Buffer Tubes

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NOTE: Quantity of fiber and colors of buffer tubes are defined by the project requirements.
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[Sheet 7, paragraph 4.2.7.2, entitled, "72-Fiber Cable", change to, "The fiber cable must contain 72 SM fibers, with a cable core configuration comprised of at least 6 loose buffer tubes each containing a 12-fiber bundle."

Sheet 7, paragraph 4.2.7, entitled, "The Number of Fibers Per Tube Per Cable", add a fourth type of cable, a 12-fiber cable and add paragraph 4.2.7.4 as follows:

"4.2.7.4 The 12-fiber cable must contain 12 SM fibers with a cable core configuration comprised of 2 loose buffer tubes. These buffer tubes must contain 6 SM fibers in each buffer tube."

Sheet 7, renumber existing paragraph 4.2.7.4 to, "4.2.7.5".]

2.2 CABLE IDENTIFICATION SYMBOL CRITERION

The first of three lines on the ID symbol must employ the following seven (7) characters:

First, Second, and Third Characters: The first, second, and third characters (from left to right) denote the number of active optical fibers in the cable.

Fourth Character: The fourth character must be a slash.

Fifth, Six, and Seventh Characters: The fifth, sixth, and seventh characters must denote optical transmission windows which the optical fiber can support. These windows are defined herein as follows:

a. The fifth character must be an "A" or an "O". The "A" denotes a window at a wavelength of 850 nanometers (nm), with an attenuation of 4 dB/km and a bandwidth of 800 MHz-km. The character must be an "O" if these requirements are not met.

b. The sixth character must be a "B" or an "O". The "B" denotes a multi-mode window at a wavelength of 1,300 nm, with an attenuation of 1 dB/km and a bandwidth of 1 GHz-km, or a single mode window with an attenuation of .5 dB/km. The character must be an "O" if these requirements are not met.

c. The seventh character must be a "C" or an "O". The "C" denotes a multi- or single mode window of a wavelength of 1,550 nm, with an attenuation of 0.5 dB/km. The character must be an "O" if these requirements are not met.

The two lower lines of the cable ID symbol must indicate multi-mode or single mode fibers, cable number and fiber count.

Example: 072/OBC Identifies the number of optical fibers (72) and the optical transmission window (as indicated above).

FM50: 141-200: Identifies Multi-Mode Fiber Cable 50 with Fibers 141 through 200.

and FS50: 25-36: Identifies Single Mode Fiber Cable 50 with Fibers 25 through 36.

2.3 SPLICE ORGANIZERS AND ENCLOSURES

The single mode or multi-mode fibers must be fusion spliced with a protective sleeve covering (buffer tubing) and stored in an organizer. For each fiber, a minimum of 18 inches of spare coiled fiber in buffer tube is required. The single mode fibers must be spliced last in the splice tray.

All splices must be housed in a "closure within a closure" scheme, in which the area between the inner and outer closure is totally filled with a re-enterable encapsulating compound.

The inner closure must house and support a splice tray organizer which holds in-place, up to 12 splice trays. The splice trays must house a splice block for protected fusion splices and hold 12 or 24 splices. The tray must be large enough to route the fibers before and after each splice such that there are no detrimental effects to the signal properties at the wavelengths specified for the fiber. Each splice tray must have its own cover.

The outer closure must be suitable for a straight, butt, or branch splice and provide a protective housing made to receive an encapsulating compound. The splice case must be made of thermoplastic, thermoset, or stainless steel material, with structural members as part of the mold (i.e., ribs or waffle structure). The encapsulating compound must be re-enterable and must not alter the chemical stability of the closure or any cable part. It must be fast curing and adhere to surfaces throughout

its expansion. The encapsulating compound must act as a moisture block and must be safe to the touch and contain no Isocyanates. Dry encapsulant must not be used. End plates must be factory drilled to fit the cable(s) outer diameter. AMP and Siecor (or equal, as approved by the Contracting Officer) are suppliers of approved splice cases.

2.4 PRE-CONNECTORIZED CABLE ASSEMBLY

Supply a factory assembled pre-connectorized cable assembly to interface with the patch panel bulkhead feed-through receptacle for each terminated fiber. The fiber in the pre-connectorized cable assembly must be manufactured by the same manufacturer as in the multi-fiber cable. Both the cable assembly connector and the bulkhead receptacle must be manufactured by the same manufacturer. The jacket for the assembly must be a single fiber 900 micrometer tight buffered cable, riser rated as OFNR cable by the NEC. Supply and install dust caps for all terminated fibers.

The connector/cable interface on both the single and multi-mode assemblies must withstand a tensile force of .45 kg25 pounds without detrimental affects on the optical dB loss characteristics.

Before the pre-connectorized cable assemblies are shipped to KSC, a Contracting Officer's representative may be required to visit the assembly and polishing site to inspect the assembly and quality control procedures, as well as random samples of the finished assemblies. If this is done, verify test requirements as indicated in other portions of this specification at the same time.

2.4.1 Multi-Mode Cable

The multi-mode connector and bulkhead assembly (coupler) used to terminate and test the fibers must be the equivalent of the AT&T enhanced multi-mode ST connector and coupling. The coupling must be made of metal and must be the bayonet/flange type. The connector must have a metal housing and a zirconia ceramic ferrule. The connector must be PC polished finish and be terminated on a three (3) meter length of multi-mode fiber jacketed as a single fiber cable. Each connector half must exhibit a loss of 0.5 dB or less. Additional approved manufacturers include 3M and Porta Systems.

2.4.2 Single Mode Cable

The single mode connector and feedthrough adapter (coupler) used to terminate and test the fibers must be the equivalent of the AT&T enhanced ST connector and coupling. The coupling must be made of metal and must be the bayonet/flange type. The connector must have a metal housing and a zirconia ceramic ferrule. The connector must be PC polished finish and terminated utilizing heat cured epoxy on a three (3) meter length of single mode fiber jacketed as a single fiber cable. Each connector half must exhibit a loss of 0.5 dB or less. The return loss for each connector must be -30 dB or better. Additional approved manufacturers include 3M and Porta Systems.

2.5 LOOPBACK JUMPER BUNDLE ASSEMBLIES

Use jumper bundle assemblies to perform loopbacks of fibers within the CXT Buildings, as part of the High Density Cross-Connect System. They must consist of either single mode or multi-mode optical fibers, having the same specifications as the outside plant optical fibers described above. The jumper bundles must consist of six (6) individual optical fibers having 900

micron jacketing material. Each bundle must contain either six (6) single mode fibers or six (6) multi-mode fibers (fibers of different types must not be mixed within jumper bundles).

The jumper bundles must not contain connectors. All loopbacks of fibers must be performed using a re-enterable mechanical splice as described in other sections of the specification.

Fibers within each jumper bundle must be color coded using the same scheme as the outside plant fibers, i.e., they must have the colors blue, orange, green, brown, slate, and white.

Cut jumper bundle assemblies to necessary length from standard sized cable reels.

2.6 FIBER OPTIC TERMINAL ASSEMBLIES

Make all cable terminations within buildings other than the cross-connect buildings in fiber optic terminal assemblies. Fiber optic terminal assemblies must be the pre-assembled "Optima Instrument" chassis and associated rack-mounting hardware manufactured by the Optima Enclosures, or equivalent.

2.6.1 Splice Trays/Cable Assembly Splicing

To facilitate the transition between outside plant cable and the pre-connectorized cable assemblies, the fibers must be fusion spliced and protected with a heat shrink protective tubing slid over the splice. The splice must be held in a splice tray large enough to route fusion splices. The splice block must be affixed in a splice tray large enough to route fibers before and after each splice, such that there are no detrimental effects to the signal properties at the wavelengths specified for the fiber. Each splice tray must have its own cover. Position the splice tray in the fiber optic terminal assembly as indicated on drawings, and provide a minimum of 18 inches of spare coiled fiber in buffer tube in the patch panel before the splice tray. Attenuation of the fusion splice must not exceed 0.2 dB.

2.7 FIBER OPTIC TERMINAL (FOT) BAY CABINET

The FOT cabinet in the VABR, must be Optima Enclosure's "Optima Vertical Cabinet", Model No. R Series, or approved equal. The cabinet's frame must consist of vertical and horizontal tubular aluminum extrusions, with a minimal wall thickness of .150 inches. Front to rear aluminum extruded corners must be at least .125 inches in thickness. Rear door, top panel, and side panels must be a minimum of 18 gauge steel. Provide cabinet with 14 gauge steel, .281 inches punched panel/chassis mounting rails permitting recessed installation of equipment. Place cable entry and exit holes as shown on drawings. Dimensions of cabinet and associated cabinet hardware are as shown on drawings.

Remove side panels of new and existing FOT's for adjoining cabinets, unless otherwise indicated on drawings. Cabinet must be gray in color. Quantities and sizes are as shown on drawings.

Optima accessories required for FOT cabinets:

a. Connection Kit HW-67 for adjoining cabinets.

b. Doors: Solid rear door, typical, Model No. D-7724nn Plexiglass front door, typical, Model No. 2D-7724nn-K "nn" is replaced by RH or LH, depending on location. Specific door ordering information is indicated on drawings.

Additional approved manufacturer of FOT cabinets and accessories include Great Lakes Case and Cabinet Company, Inc., of Edinboro, Pennsylvania.

2.7.1 12-Fiber Termination Panel

The 12-fiber termination panel to be Siecor WIC-12, or approved equal. The termination panel must be mountable on a plywood backboard. It must contain removable splice trays capable of housing pigtail fusion splices with heat shrink protective sleeves. It must contain a connector panel capable of terminating all fibers.

2.8 HIGH DENSITY FOT CROSS-CONNECT SYSTEM

Use high density FOT bays in the CXT Buildings only. The high density bays must be capable of terminating no less than nine (9) 144-fiber cables in one 7 foot bay. The bay must consist of up to nine (9) individual splice modules, each module having the capacity to terminate 144 outside plant fibers.

The high density bay must include all necessary accessories to allow the routing of cross-connect jumpers, both within the bay and to adjacent bays within the same line-up.

The following are acceptable manufacturer's of high density bays: ADC, AT&T, Porta Systems, and 3M. The following information is provided in order to describe other products available from the manufacturers listed above, which also conform to the specifications of the high density cross-connect frames.

AT&T Network Systems: The LGX fiber optic distributing frame and LDS (Lightguide Distribution Shelves) are used to create high density fiber frames. In order to terminate the required 144 fibers in each LDS, use the LSS1U-144 Lightguide splice shelf. Up to nine (9) of these units can be placed in one 7 foot bay.

Porta Systems: The Fiber Optic Connection Universal System (FOCUS) Fiber Distribution Frame (FDF) is used with the Universal Housing in order to create the high density fiber cross-connect bays. The universal housings must be equipped with six (6) "Maximum Density" splicing shelves, which contain 28 splices each. Up to nine (9) housings can be located within one 7 foot bay.

3M: The 2400 Series High Density Fiber Cross-Connect System provides rack mounted high density cross-connect capability in a 23" x 7' rack. Mount five cross-connect cabinets (Model 2430) in a standard 23" rack. Each cabinet must contain 24 high density connector cards (12 each of Model 2411 and Model 2413). Furnish and install (12) connectors (Model 2401) on each connector card. The connectors must function as the re-enterable mechanical splices for the 3M cross-connect system.

Certain elements must remain common to the cross-connect system, regardless of the cross-connect manufacturer selected. These must include, but not necessarily be limited to to the following: (1) top, side and rear jumper routing channels and/or troughs which allow manageable routing of jumpers

between splice locations; (2) rear doors; (3) necessary hardware to secure frames to floor; (4) cable clamps which secure outside plant cables to the splice frames; (5) all necessary tools required to perform the mating/remating of the mechanical splice, and (6) all necessary labeling kits in order to adequately label the number of each fiber which terminates in the CXT's. Provide all of these elements with the high density cross-connect frames, regardless of which manufacturer or vendor furnishes the cross-connect system. These elements can be furnished as an integral part of the vendor's cross-connect system, i.e. jumper routing troughs can require additional items to be purchased and installed, which are not included with the cross-connect system.

2.9 FIBER SPLICING

Outside plant fiber splices must be fusion type and made along the fiber route where indicated. The splices must exhibit an insertion loss not greater than 0.2 dB. All splice measurements must be made at 1300 nm, plus or minus 5 nm. All splices must be mounted in splice trays (See Section 2.6.1 for size and type). The number of cable splices must not be increased.

2.10 TEST PLAN

Submit for approval, a test plan (SD-88) showing when and how each system is to be tested, 30 days in advance of actual testing. Also submit a testing validation procedure, which must be itemized to the extent that permits recording the tested parameters including space for sign-off witnessed by the Contracting Officer's Technical Representative.

Submit the test schedule to the Contracting Officer's representative for approval, 30 days prior to the start of testing.

2.11 TEST RESULTS

Submit the Contractor test results for approval in accordance with Section 01 33 00 SUBMITTAL PROCEDURES no later than ten (10) working days after the completion of each type test. Test forms are included at the end of this section.

2.12 SPARE MATERIAL FOR CROSS-CONNECT TERMINAL FACILITIES

In addition to the materials required to install the high density cross-connect system as described in the drawings and specifications, the contract must also include additional materials to provide capability for operations personnel to perform future cross-connects of unterminated fibers. Include the following items: (1) additional 6 fiber jumper bundle cables (one additional reel [1 km minimum] of both single mode and multi-mode cable); (2) additional re-enterable mechanical splices or connectors (10 percent surplus beyond total number required for testing); (3) additional tools required to perform the re-enterable mechanical splice and/or the cross-connection operation between fibers in the CXT facilities (two additional sets of all necessary tools must be provided).

2.13 RE-ENTERABLE MECHANICAL SPLICES

All fiber splices within the CXT high density cross-connect systems must be made using a re-enterable mechanical splice. Acceptable splices must include the GTE Fastomeric Mechanical Splice, the AT&T CSL Mechanical Splice, the Norland UVC Mechanical Splice, the 3M High Density Fiber Optic

Connector, or approved equal. The term "re-enterable" must be taken to mean that the splice is designed to have the fibers being spliced, removed and re inserted without degrading optical performance or physically damaging the fibers. Splices which are designed to permanently secure the fibers within the splice are not to be used.

The splices must be designed to allow a 250 micron fiber (the outside plant fiber) to be spliced to a 900 micron tight buffered fiber (the CXT jumper bundle assembly fiber). Use the re-enterable mechanical splice to perform test cable splices as described in other portions of this specification.

2.14 INDOOR CABLE (OFNR/OFNP)

Use OFNR (Optical Fiber Nonconductive Riser) cable in buildings where fiber cable runs longer than 15.2 m50 feet, and outside conduit are necessary, and where cable is routed between building floors or routed within non-air handling areas.

Use OFNP (Optical Fiber Nonconductive Plenum) cable in buildings where fiber cable runs longer than 15.2 m50 feet, and outside conduit are necessary, and cable is routed through plenum or air handling areas.

Both OFNR and OFNP cable to be as defined in NFPA 70.

OFNR/OFNP cables must contain materials which give the cables suitable strength to allow them to be placed in ducts and cable tray systems, along with other communication cables.

2.15 CABLE RACKING MATERIALS

Use cable racking inside buildings to support fiber optic cables. The racking material must be channel type, rather than trough type, and must be constructed of steel material. The rack sections must consist of tubular side bars spaced on 305 mm12" centers. All fittings and connecting hardware required for bends, offsets, and junctions must be compatible with the rack sections.

PART 3 EXECUTION

3.1 GENERAL

Cable construction work must be performed by construction personnel who are experienced in placing cables in conduit, cable trays, and underground duct systems.

Fiber optic cable splices, terminations and testing must be made by journeymen cable splicers who are experienced in splicing and terminating, and one year in testing fiber optic cables.

Each individual who is to perform fiber optic cable splicing is required to perform a minimum of one acceptable sample splice and termination. Sample splices and terminations must not be incorporated in the job. The qualifications for all personnel to perform splicing and terminations and testing must be submitted to the Contracting Officer for approval, 30 days prior to start of installation.

3.2 CABLE

Provide cables in continuous lengths as required to accomplish the required

installation without splices from termination to termination, except where field splices are specifically shown on the contract drawings. If the Contractor deems it necessary to change or eliminate any splice, or make any other than those shown on drawings, the Contractor must submit reasons therefore, and the proposed splicing techniques to the Contracting Officer for approval. Provide the splices, if approved, at no additional cost to the Government. Terminate all cables with appropriate connectors and associated hardware at all locations, except when indicated otherwise on the contract drawings.

3.3 FIBER SPLICES

The completed fusion type splice must be covered with a protective sleeve (heat shrink type or approved equal) to restore the protective properties of the fiber coating and buffering. Deviations to the splice location and pulling plan are permitted, upon approval by the Contracting Officer.

All fiber colors must be continuous from end to end. No switching or staggering of color scheme within the cable at splice points is allowed. Exception to this must take lace when splicing one 144-fiber cable to two 72-fiber cables. In all cases, splice fibers according to the cable number and fiber count. See contract drawings for details. Splice fibers in numerical order according to the fiber counts as shown on the drawings, with multi-mode fibers identified first and single mode fibers at the end.

Bring the cables out of the manhole into a controlled environment to perform the fiber fusion splice operation. Complete the splice by returning the cable to the manhole and routing the cable around the manhole interior in a neat and orderly manner, such that the excess cable does not impede future entrance and utilization. The cable is to be secured at regular intervals.

3.4 WORK IN MANHOLES AND CABLE VAULTS

Ensure that safe operating procedures are followed, work equipment is adequate, and personnel have received proper training. All atmospheric tests must be conducted by others, prior to Contractor personnel entering a manhole or vault. Safety equipment must be inspected and approved by an authorized representative of the Contracting Officer.

Use of torches, furnaces or other open flame, heat generating devices or smoking is not permitted in manholes.

Protect open manholes by fences, railings, signs, flags, or lights, as applicable. Body static electricity that has accumulated must be discharged to ground prior to personnel contact with manhole covers. Removal of manhole covers must be performed by two men using hooks and employing proper lifting techniques. Remove all manhole covers in the immediate vicinity of the duct system where work is to be performed to permit adequate ventilation.

Each time work is begun, remove or pump excessive water from the manhole vault or duct run, as required, prior to personnel entrance.

A manhole entry permit is required for every manhole entry. This permit is issued by Environmental Health personnel employed by NASA or one of its contractors.

Perform vapor tests to ensure that the presence of explosive gases is below

dangerous concentration levels (less than 25 percent by volume).

Perform above environmental tests each time work is started or at the initial crew change, and repeat in a time interval not to exceed 8 hours. If prolonged forced ventilation is required, the time interval for additional tests must not exceed 2 hours.

Two persons must be present during manhole operations: one man enters the manhole, the other must remain outside. The outside man must be equipped with a communication device to call for help if necessary, as specified by OSHA 1710.2B.

Operate blowers continuously while work is being performed and until work is completed.

Environmental tests must indicate atmosphere is safe prior to personnel entry.

Blowers or ejectors must not be placed in the manhole or cable vault, but must be located on the surface at a distance not less than 5 feet from the open manhole or cable vault, to assure a safe operating atmosphere.

Use ladders of the proper length and type (wood or fiberglass) for entry into manholes.

Locate all engine driven equipment downwind from manholes.

3.5 CABLE PLACEMENT

The contract drawings show the general location of the cables and equipment to be placed. The Contractor is responsible for surveying the installation to determine obstacles to installation and the exact locations for cables and equipment to be installed. Any conditions that precludes installation of cables and equipment in the location shown on the contract drawings must be immediately reported to the Contracting Officer.

Maintain a minimum of 305 mm12 inches between communication cabling and power conductors.

3.5.1 Securing Cable

Immediately after cable placement, attach a permanent identification tag as indicated on drawings to visible cable sections. Check the cables to ensure that the markings are intact.

Support and secure cables and equipment as shown on the contract drawings. Where the specific method of support is not shown, use adequate supports and fasteners to secure cables and equipment in position. Metallic supports and fasteners must be hot-dipped galvanized steel in manholes and vaults having metallic cable racks, and must be non-metallic material in manholes and vaults having non-metallic racks. Route all cables along the interior sides of manholes.

Two or more cable hooks or cable rack arms are required per manhole.

Use clamps and Ty-Raps as necessary to properly secure the cable.

3.5.1.1 Bending

Use caution when bending cable to avoid kinks or other damage to the sheath. The bend radius must be as large as possible, with a minimum of 10 inches. Increase minimum radius when necessary to meet cable manufacturer's recommendation. Cables must not rest against the edge of the duct conduit mouth, the 30 inch manhole opening or other sharp edges.

Unless otherwise approved, the cable must be pulled and spliced in the manner and at the locations specified in the drawings.

3.5.1.2 Pulling

Pull cable into the duct system using equipment designed for this purpose. This equipment must have the capability to continuously monitor the cable pulling tension. Submit SD-30 on this equipment and include calibration data. The cable pulling tension must not exceed 600 pounds.

Cable pulling using vehicles is not permitted.

Employ a sufficient number of trained personnel with 2-way radio communications equipment, to ensure proper installation of the cable.

Attach pulling lines to both cable ends when cable is destined for bi-directional pull, and fitted with factory-installed pulling eyes as shown in AFTO 31W3-10-12, Figure 10-34. Exception to this can be implemented for pulling 144-fiber cable in 1 inch inner duct; submit pulling plan as required SD. Cables not equipped with a pulling eye must have the pulling line attached to the cable end by means of a cable grip, installed as shown in AFTO 31W3-10-12, Figure 10-34. Core hitches must not be used.

Locate cable reels and aligned so that the cable is paid out from the top of the reel into the duct or conduit in a long, smooth bend, without twisting. Cable must not be pulled from the bottom of the reel. Use a cable feeder guide of proper dimensions at the mouth to guide the cable into the duct or conduit.

Set up rigging at the pulling end so that the pulling line and cable exit on a line parallel with the duct or conduit, to prevent either from rubbing against the edge or mouth. Cable ends must not be pulled around sheave wheels. When the sheave or pulley cannot be positioned to obtain sufficient cable end slack for proper racking and splicing with the pulling line attached to the end of the cable, a split cable grip can be used to obtain the necessary slack.

3.5.1.3 Lubricant

Use adequate pulling lubricant, Hydra-lube F-100, manufactured by Arnco, Westlake, Ohio or approved equal to minimize pulling tension and prevent sheath damage when pulling cables into ducts and conduits. Apply lubricant to the cable sheath with a lubricator. When pulling has been completed, wipe the exposed cable ends clean of lubricant. Clean up all lubricant spills immediately.

Lubricants must be certified by the lubricant manufacturer to be compatible with and intended for use with plastic-sheathed cables. Soap and grease type lubricants are prohibited.

Carefully check all equipment and the pulling set to minimize interruptions once pulling begins. When possible, the cable must be pulled without stopping, until the required amount of the cable has been placed. If for any reason the pulling operation must be halted before the pull is completed, the tension of the pulling line must not be released. When pulling is resumed, the inertia of the cable must be overcome by increasing the tension in small steps a few seconds apart until the cable is in motion. The cable must be paid from the top of the reel by rotating the reel in the feed direction at the rate of pull. The cable must not be stripped off the reel by pulling.

3.5.1.4 Damage and Defects

Ensure, by means of a tension monitoring device, that the cable pulling procedures being used do not exceed the maximum pulling tension, as specified by cable manufacturer.

Carefully inspect the cable for sheath defects or other irregularities as it is paid out from the reel. If defects are detected, pulling must stop immediately and the cable section must be repaired or replaced at the discretion of the Contracting Officer. Maintain a system of communications, visual or otherwise, between pulling and feed locations so that pulling can be stopped instantly, if necessary.

When making pull-throughs, use a man in the intermediate manhole(s) to guide the cable into the next duct section. Use proper rigging in the intermediate manhole(s) to keep the pulling line and cable aligned with the exit duct, to prevent the line or cable from rubbing against the edge of the duct. Cables in pull-through manholes must be set up and racked before the cable ends in adjacent manholes are set up and racked. Exercise caution during the pulling operation to avoid excess slack and prevent kinking or any damage to the cable.

Cable ends pulled into manholes, vaults, or terminal locations that are not to be racked or otherwise permanently positioned immediately must be tied in fixed positions to prevent damage to the cables and provide adequate working space.

3.5.1.5 Duct Seal

Inner duct in which cable is placed must be sealed with insta-foam duct seal or approved equal to prevent damage to the cable sheath and to prevent the entrance of dirt or water into the inner duct. All unused inner duct installed on this project must be sealed at both ends by using Aeroquip part No. IP1052W, or approved equal.

3.5.2 Cabling Installation in Cable Trays

Communication cables must not be installed in the same cable tray with AC power cables.

Cables placed in cable trays must be installed in a neat and orderly manner and must not cross or interface other cables, except at break-out points.

Cables in vertical trays must be individually retained with Ty-Rap straps or equal, a maximum of 6 feet on center.

3.5.3 Cable Delivery

Deliver the replacement cable reels to the Government as directed by the Contracting Officer.

3.6 SEQUENTIAL CABLE RECORD

The sequential cable markings along the cable prior to and after each end of splice point, must be recorded on the sequential cable form and submitted for approval. A sample form is included at the end of this section.

3.7 SPLICE CLOSURE OPERATIONS

Prior to encapsulation of all completed fiber splices, the Government will inspect each splice and approve workmanship.

Encapsulating compound must be placed between inner and outer closures only under well ventilated conditions. Avoid breathing of vapors. Safety glasses or goggles and impervious or non-penetrable gloves are required. Also avoid eye and skin contact.

Filling compounds within the cable jacket can be removed by using "Hydrasol" cleaner, made by American Polywater Corporation, Stillwater, Minn., or approved equal, or other product recommended by the specific cable manufacturer.

3.8 GROUNDING SYSTEMS

Metallic cabling must be grounded at each termination point or as indicated on the contract drawings.

3.9 TESTING

All test equipment, test procedures, and testing techniques must be specified in the acceptance test plan and requires approval prior to execution. Tests must be conducted by the Contractor in accordance with the approved Test Plan. The purpose of this testing is to verify that the installed fiber optic cable system meets all specified attenuation and bandwidth requirements and is capable of being used for its intended purpose. Field tests must be witnessed by the Government technical representative. As stated elsewhere in the contract, the Government technical representative must be given twenty (20) working days notice, prior to performing each test.

Submit test results for approval. Manufactured or assembled products or equipment must be tested as indicated, and the results submitted to the Contracting Officer for approval, prior to shipment to the site. Additional tests must include tests of the reeled cable, as well as pre-connectorized cable assemblies. All test leads must be of the same type, same specification and manufactured by the same firm as that of the multi-fiber cable, or as otherwise stated by the test equipment manufacturer. Perform OTDR tests on each fiber after splicing operations. Make final installation tests end-to-end. Test must be made on all fibers in both directions.

3.9.1 Test Plan

Prepare a test plan which provides a detailed outline of all testing to be

accomplished. The test plan must address whether cladding modes have been stripped prior to testing, source wavelength (peak), spectral width full width/half maximum (FWHM), mode structure, fiber end preparation, and bandwidth measurements of fiber links both greater and less than 1 km. The test plan must include, as a minimum, a schedule of when tests are to be performed (relative to installation milestones), specific test procedure that are to be used, a list of test equipment to be used (manufacturer, model number, range, resolution accuracy) and must conform to the specified requirements of other sections of this specification.

3.9.2 Test Results

Each test sheet must have a sign-off blank for the Contractor, as well as the contract technical representative. Deliver copies of the completed test forms or test results according to the shop drawing to the shop drawing procedures.

Maintain an accurate test record during all field tests. Samples are attached at the end of this section. Use of these sample formats are not mandatory, but any Contractor-developed format for recording test data must be submitted for approval as part of the test plan. Submit tests as directed by the requirements of the following sections.

3.9.3 Factory Tests

Make and submit manufacturing or factory tests to the Contracting Officer for approval, prior to shipment of material to the site.

3.9.3.1 Multi-Fiber Cable Tests

Use specification 79K28125, Revision K, as the basis for optical and mechanical performance test requirements. Perform mechanical bend radius, tensile strength, crush resistance and impact resistance test required by 79K28125, Revision K, on each lot or design type of cable. The results of these tests together with the numerical aperture, attenuation and bandwidth tests of each reel of cabled fiber must be submitted in accordance with the referenced EIA Standards. See sample test form at the end of this section.

3.9.3.2 Pre-Connectorized Cable Assembly

Attenuation of each assembly must be made and submitted for approval prior to shipment to the site. The method of testing must be in accordance with 79K28125, Revision K, and must be included in the acceptance test plan. See sample test form at the end of this section.

3.9.4 Tests During Installation

Perform Optical Time Domain Reflectometer (OTDR) tests during cable installation splice operations. Fiber alignment must be made according to the OTDR read out to minimize the loss as the fusion splice is completed. A sample form is included at the end of this section.

A 1 km (minimum) fiber delay line is required between the OTDR and the first connector and after the far end connector. Splices not conforming with the maximum attenuation requirements must be reworked to conform.

If after three attempts, the specified value is not obtained, then a NASA Engineering Evaluation is required before further splicing commences. Record OTDR values for all splices in the presence of the technical

representative.

Submit the recorded values to the Contracting Officer for approval within one (1) work day of said record being made.

3.9.5 Installation Completion Tests

After terminations and splices have been completed, each fiber must have an OTDR fiber trace made for the entire span, including a 1 km (minimum) fiber delay line before the first connector and after the last connector. Perform this test in both directions. Submit these OTDR records to the Contracting Officer for approval within fourteen (14) calendar days. Final acceptance is based on the final end-to-end attenuation and bandwidth test. Final acceptance of pre-connectorized cable assemblies is based on OTDR measured patch panel loss after installation.

Submit all OTDR Final Acceptance Test Data on 89 mm3.5" diskettes. Use an OTDR having this capability. Provide three (3) sets of this data.

Provide three (3) sets of legally registered and licensed PC-based OTDR-emulation software (including documentation) which is compatible with the OTDR used during testing. The software requirement will be waived by the Government if one of the following OTDR/software combinations is used for the testing.

a.	ANRITSU	MW9040B MX3602B	OTDR OTDR Emulation Software - 1st Edition (1994)
b.	TEKTRONIX TFP2	OTDR TFP2	 Fiber Master Trace Analysis Package (FMTAP) Emulation Software - Version 2.00 (1993) Fiber Master Utility Disk - Version 1.02 (1993)
c.	Laser Precision Corp.		TD 350 Version 2.29 (3/26/96) PC-3000 OTDR Emulation Software
d.	Siecor (Corning)		OTDR 2001-PC OTDR Emulation Software V1.10 (5/26/92)

3.9.6 Final Acceptance Tests

Make final acceptance tests after all other tests are performed and approved. Final acceptance tests measure attenuation and bandwidth of installed fibers. Sample forms are included at the end of this section. Submit completed forms to the Contracting Officer for approval within three (3) working days of test.

3.9.6.1 End-to-End Attenuation Test

Measure attenuation at the 1300 nm and the 1550 nm wavelength of both the single mode and the multi-mode fiber using the insertion loss method, performed in each direction. The measurement requires the use of a stable light source and a light meter, both with a designated jumper cord whose far end connector is the type an make of the installed fiber being measured. The light source jumper cord must wrap around a 1/2 inch

diameter mandrel a minimum of five (5) times. The light source cord must be connected to the light meter cord by means of a Bulkhead Assembly/Fee Through Adaptor (same type as system to be measured) and the meter reading must be set to zero or used as the reference loss. The light source must then be connected to one end of the fiber under test and the light meter to the other end, and the meter reading recorded. If the meter had a reference loss, it must be subtracted from the recorded test reading to determine the loss. Fibers used during test must meet the same specifications as the fibers under test.

The measured loss must not exceed the calculated loss. The calculated loss (Lc) must be shown as:

Lc(multi-mode, 1300 & 1550) must be equal to
lt(1 dB/km)+n1(.2dB)+n2(.5dB)

Lc(Single mode, 1300 & 1550) must be equal to
lt(.5dB/km)+n1(.2dB)_n2(.5dB)

Where lt is the length in kilometers of the fiber to be tested, n1 is the number of splices in the length to be tested, and n2 is the number of connector halves in the length to be tested.

Perform end-to-end attenuation tests at both 1310 nm and 1550 nm on both multi-mode and single mode fibers. Judge the multi-mode fibers acceptable only on the basis of the 1310 nm window tests; perform the 1550 nm tests for record purposes only. The single mode fibers must be judged acceptable on the basis of both windows, i.e., each fiber must meet the requirements for both 1310 nm and 1550 nm.

3.9.6.2 End-to-End Bandwidth Test (Multi-Mode Only)

Measure the end-to-end bandwidth utilizing frequency domain method. Measure the bandwidth in both directions on all multi-mode fibers and record measurements. The bandwidth at -3 dB optical power of each optical fiber in the cable must be a bandwidth length product greater than 1 GHz-km within a peak optical emissive region of 1280-1330 nm. This test must be made at the completion of the testing. See sample test form at the end of this section. Show the calculated bandwidth (BWc), with Gamma equal to 1, as:

For fiber length less than 1 km;
BWc must be greater than or equal to 1 GHz

For fiber length greater than 1 km;
BWc must be greater than or equal to 1GHz-km/lt

Where lt is the length in kilometers of the fiber to be tested.

3.9.6.3 Acceptance Tests of Loopback Fibers

Fiber cable installed within the CXT facilities is subject to the same acceptance tests as described above.

Fibers which are looped back within the CXT facilities must be tested end-to-end through the CXT and back to the originating facility. When testing through the CXT's, the re-enterable mechanical splices required here must be treated in the end-to-end attenuation budget as separate field splices, i.e., allow a total of 0.2 dB in the budget for the CXT's

mechanical splice connector loss.

3.10 TEST EQUIPMENT

The test equipment used for verifying installation testing must be calibrated by a certified testing company within three (3) weeks of use, and meet the following requirements:

3.10.1 Optical Time Domain Reflectometer (OTDR)

Operating wavelengths: 1,300 plus or minus 20 nanometers

Attenuation Range (one way): Minimum 15 dB at 1,300 nm

Attenuation Resolution: 0.01 dB

Accuracy: plus 0.5 dB

Display: OTDR's must have digital readout capability and must have a means of providing a permanent record of the fiber trace on 89 mm3.5" diskettes.

OTDR PC Software: See 3.9.5

3.10.2 Attenuation Measurement Test Set

An attenuation measurement test set must consist of an optical power meter and an optical power source. The attenuation measurement test set must be traceable to NBS standards for stable optical source. The meter can be analog or digital. The following requirements must apply:

Operating wavelengths: 1,300 plus or minus 10 nanometers

* The Government will provide the Contractor with a power meter and light source to complete testing at the 1550 nm window for multi-mode fiber only.

Attenuation Range: at least 30 dB or better at 1,300 nm

Attenuation Resolution: 0.01 dB

Accuracy: The accuracy of the attenuation measurement test set must be plus or minus 5 percent.

The optical source must be capable of coupling sufficient power into the fiber so that the light received at the meter is within the meter detectability limits.

3.10.3 Bandwidth Measurement Equipment

All bandwidth measurement equipment must meet the following requirements:

a. Operating wavelengths: 1,300 plus or minus 10 nanometers

b. Bandwidth Range: minimum 1000 megahertz

c. Bandwidth Resolution: 1 megahertz

d. Accuracy: The accuracy of the bandwidth measurement equipment must be plus or minus 0.5 megahertz.

e. Measurement Method: Swept Frequency

3.11 TABLES

SAMPLE DATA FORM, PARAGRAPH 3.6

SEQUENTIAL CABLE MARKINGS

CONTRACT NAME/NUMBER:_____

FROM BLDG:_____ TO BLDG./END POINT_____

LENGTH _____ km. CABLE NUMBER_____

BUILDING MANHOLE	LOCATION	READING	DISTANCE
	START POINT		km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
	END POINT		km
TOTAL (START TO END)			km

TEST CONDUCTOR:_____ DATE:_____

CONTRACTING OFF. REP._____ DATE:_____

SAMPLE DATA FORM, PARAGRAPH 3.10.6.2

FACTORY CABLE DATA (REELED)

CONTRACT
NAME/NUMBER:_____

CABLE MFG.:_____ DATE:_____

ADDRESS:_____ REEL NO._____

CABLE IDENTIFICATION:_____ REEL LENGTH_____km

FIBER CA NO	TUBE AND FIBER COLOR	BANDWIDTH (MHz-km) 1300nm	ATTENUATION (dB/km)		NUMERICAL APERTURE
			1300nm	1500nm	

TEST CONDUCTOR:_____ DATE:_____

CONTRACTING OFF. REP._____ DATE:_____

SAMPLE DATA FORM, PARAGRAPH 3.10.6.1

END-TO-END ATTENUATION TEST

CONTRACT
NAME/NUMBER:_____

BLDG LOC._____ TO_____ FROM_____

CABLE NO._____ NO. CONNECTORS_____ NO. SPLICES_____

CALCULATED ATTENUATION:_____dB TEST REFERENCE LOSS:_____dB

TEST WAVELENGTH:_____

FIBER NO.	COLOR TUBE/ FIBER	FIBER UNDER TEST (dB)	NET LOSS (dB)	FIBER NO.	COLOR TUBE/ FIBER	FIBER UNDER TEST (dB)	NET LOSS (dB)

TEST CONDUCTOR:_____ DATE:_____

CONTRACTING OFF. REP._____ DATE:_____

SAMPLE DATA FORM, PARAGRAPH 3.10.6.2

END-TO-END BANDWIDTH TEST

CONTRACT
NAME/NUMBER:_____

FROM BLDG.:_____ TO BLDG./END POINT_____

LENGTH_____km CABLE NUMBER_____

CALCULATED BANDWIDTH BWc_____

FIBER NO.	COLOR TUBE/FIBER	BNDWDTH @1300nm	GHz -km	FIBER NO.	COLOR TUBE/FIBER	BNDWDTH @1300nm	GHz -km

TEST CONDUCTOR:_____ DATE:_____

CONTRACTING OFF. REP._____ DATE:_____

SAMPLE DATA FORM, PARAGRAPH 3.10.3.2

PRE-CONNECTORIZED CABLE ASSEMBLY FACTORY DATA

CONTRACT
NAME/NUMBER:_____

CABLE
MFG.:_____

ADDRESS:_____

ASSEMBLY
IDENTIFICATION:_____

CONNECTOR TYPE:_____km LOT NO._____

ASSEMBLY NUMBER	ATTENUATION (dB/km) 1300 nm	ASSEMBLY NUMBER	ATTENUATION (dB/km) 1550nm

TEST CONDUCTOR:_____ DATE:_____

CONTRACTING OFF. REP.:_____ DATE:_____

SAMPLE DATA FORM, PARAGRAPH 3.10.4

FIELD TERMINATION SPLICE RECORD

CONTRACT
NAME/NUMBER:_____

TEST LOCATION:_____ CABLE NUMBER:_____

SPLICE LOCATION:_____ LENGTH TO SPLICE:_____km

LENGTH TO END OF FIBER:_____km

FIBER NO.	TUBE COLOR/ FIBER COLOR	SPLICE ATTEMPT/ LOSS db 1 2 3	FIBER NO.	TUBE COLOR/ FIBER COLOR	SPLICE ATTEMPT/ LOSS db 1 2 3

TEST CONDUCTOR:_____ DATE:_____

CONTRACTING OFF. REP.:_____ DATE:_____

-- End of Section --